VO_2 薄膜の金属–絶縁体転移挙動の変調

Modulation of the Metal-to-Insulator Transition Behavior of VO_2 Films

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Vanadium dioxide (VO_2) shows a first-order phase transition between monoclinic insulating phase and rutile metallic phase around the phase transition temperature, T_c = 68 °C (Bulk). During the transition, its properties also change abruptly, promising for a lot of potential applications in optical, electrical, and thermal devices. However, the T_c of bulk VO_2 is relatively high and hard to control. Moreover, its phase transition is usually accompanied by thermal hysteresis which is induced by the latent heat of first order transition. These two problems seriously restrict its practical applications and become the main research focus of VO_2. Accumulating evidence suggests that the lattice constant plays an important role in the phase transition behavior of VO_2 and by using TiO_2 substrate to introduce epitaxial strain to VO_2 film, the T_c can be greatly reduced [1]. However, the expensiveness of TiO_2 single crystal limits the large-scale use.

In this study, we used rutile TiO_2 buffer layer fabricated on the (10-10) α-Al_2O_3 substrates, instead of using TiO_2 substrate, to modify the interface strain condition of VO_2 films. By controlling the thickness of TiO_2 buffer layer, the lattice parameter of VO_2 films can be continuously adjusted, further causes the regular change of T_c. Moreover, by simultaneously controlling the bilayer thickness, the thermal hysteresis can be significantly reduced. We consider these results may be useful for the design of VO_2-based device.

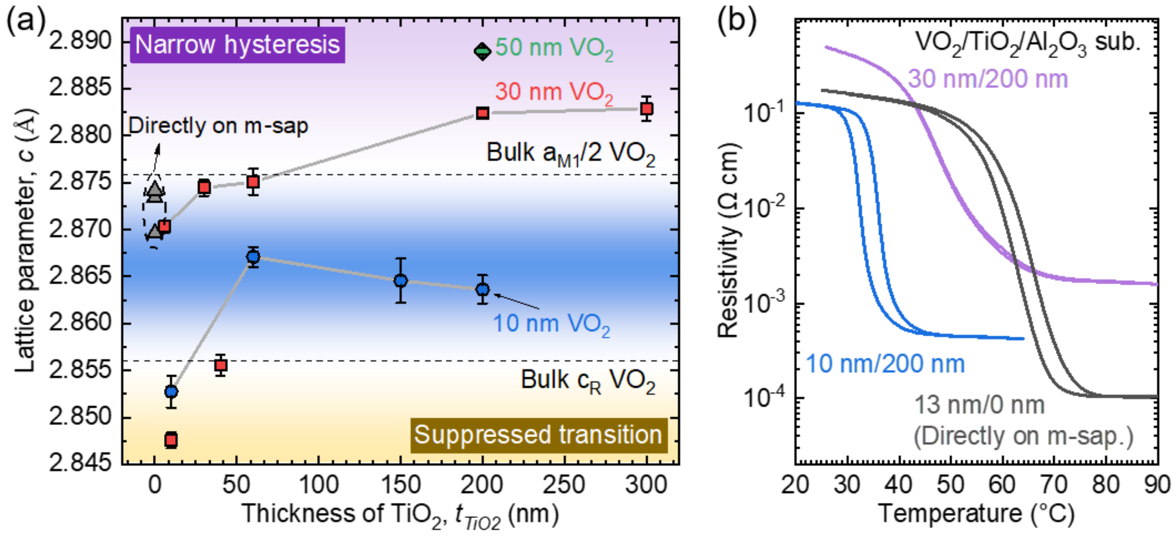

Figure | (a) Lattice parameter c as a function of the TiO_2 layer thickness. The two dashed lines indicate the half of bulk lattice parameter a of the monoclinic phase and the bulk lattice parameter c of the rutile phase of VO_2, separately. The lattice parameter of the samples shows narrow hysteresis is larger than bulk $a_{M1}/2$. **(b)** Temperature dependence of the electrical resistivity of some typical VO_2 samples in (a). The T_c of 10 nm VO_2 film decreases to the near room temperature of ~34 °C with 200 nm TiO_2 buffer layer. When increasing the VO_2 thickness, the T_c will increase but the thermal hysteresis width ΔT_c can be significantly narrowed.

[1] Y. Muraoka, Z. Hiroi, *Appl. Phys. Lett.* **80**, 583-585 (2002).